REMARKS

Claims 1, 20, 32, 35 and 55 have been amended. Claims 4, 14 and 38-54 and 56 are canceled. Claims 1-3, 5-13, 15-37 and 55 are pending in this application. Applicant reserves the right to pursue the original claims and other claims in this or other applications.

Claims 1, 4, 11, 15-18, and 56 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,489,643 to Lee (Lee) in view of U.S. Publication No. 2002/0171077 to Chu (Chu) and in further view of U.S. Patent No. 6,117,702 to Nakamura (Nakamura). The rejection is respectfully traversed.

Claim 1 recites a pixel cell for an image sensor, the pixel cell comprising, among other elements "a photodiode for generating charge in response to light and for amplifying the generated charge, the photodiode being formed within a substrate and below an upper surface thereof and comprising at least two of a first layer having a first band gap and at least two of a second layer having a second band gap, wherein the first layers are alternated with the second layers, wherein the first layers are not in direct contact with one another and the second layers are not in direct contact with one another, and wherein the at least two first layers and the at least two second layers are configured to promote ionization by a first carrier type and suppress ionization by a second carrier type in the presence of an electric field" and "a gate of a transistor adjacent to the photodiode, the transistor for transferring the amplified charge from the photodiode."

Lee fails to disclose, teach, or suggest the above noted limitations of claim 1. Instead, Lee discloses a pinned photodiode having a plurality of PN junctions to improve the capacitance of the photodiode. Lee is not concerned with a photodiode having "at least two of a first layer having a first band gap and at least two of a second layer having a second band gap, wherein the first layers are alternated with the second layers, wherein the first layers are not in direct contact with one another and the second layers are not in direct contact with one another, and wherein the at least two first layers and the at least two second layers are configured to promote ionization by a first carrier type and suppress ionization by a second carrier type in the presence of an electric field," as recited by claim 1.

Lee's photodiode is a pinned photodiode having a structure for increased capacitance and is not directed to promote charge amplification. Lee's structure, while increasing capacitance, would also result in increased noise. In addition, Lee's structure could not "promote ionization by a first carrier type and suppress ionization by a second carrier type in the presence of an electric field," as recited by claim 1.

The Office Action points to FIG. 13 of Nakamura as teaching the first and second layers of the claimed photodiode. However, the FIG. 13 photosensitive structure of Nakamura is not part of a pixel cell and is not "formed within a substrate and below an upper surface thereof," as recited in claim 1. Moreover, there is nothing in Lee or Nakamura to suggest to one skilled in the art to replace the photodiode of Lee with the photosensitive structure shown in Nakamura's FIG. 13 to achieve the pixel cell recited by claim 1.

Further, Nakamura relates to using silicon and silicon carbide. These materials are transparent to visible light and would not be suitable for a CMOS application concerned with capturing charge in the visible range as Lee's structure does. These materials would not be suitable to place in Lee's pinned photodiode as suggested in the Office Action. Further, the suggested modification would render Lee's photodiode unsuitable for its intended purposes. Thus, one skilled in the art would not be motivated to modify Lee with Nakamura as suggested by the Office Action.

Chu is cited as disclosing "a photodiode and a graded buffer layer beneath a bottom layer of the photodiode" and fails to cure the deficiencies of Lee and Nakamura. For at least these reasons, Applicant respectfully requests the rejection be withdrawn, and the claims allowed.

Claim 19 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Lee in view of Chu, Nakamura and in further view of U.S. Patent No. 6,232,626 to Rhodes (Rhodes). The rejection is respectfully traversed.

Claim 19 depends from claim 1, and is allowable over the Lee and Chu combination for all the reasons presented for claim 1, and on its own merits. Rhodes is cited as disclosing a pixel

cell where the substrate is a silicon-on-insulator substrate, and fails to cure the deficiencies of Lee, Chu and Nakamura. For at least these reasons, Applicant respectfully requests the rejection be withdrawn, and the claim allowed.

Claims 2-3, 5-8, 12-13, 20-29 and 32-34 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Lee in view of Chu, Nakamura and in further view of U.S. Patent No. 5,818,322 to Tasumi. The rejection is respectfully traversed.

Claims 2, 3, 5-8, 12, and 13 depend from claim 1 and are allowable along with claim 1, and on their own merits. Tasumi is cited as disclosing the differences between the valence band energies and the conduction band energies, and does not cure the deficiencies of Lee, Chu and Nakamura.

Like claim 1, claim 20 recites "an image sensor comprising: an array of pixel cells at a surface of a substrate, wherein at least one of the pixel cells comprises a photodiode formed within the substrate and below an upper surface thereof, the photodiode comprising at least two of a first layer comprising a first material and at least two of a second layer comprising a second material, wherein the first layers are not in direct contact with one another and the second layers are not in direct contact with one another, wherein the layers are configured such that a difference between the conduction band energies of the first and second materials and a difference between the valence band energies of the first and second materials promotes ionization by a first carrier type and suppresses ionization by a second carrier type in the presence of an electric field and wherein the first layers are alternated with the second layers" and "a gate of a transistor adjacent to the photodiode, the transistor for transferring the amplified charge from the photodiode."

Similarly, claim 32 recites an image sensor comprising a photodiode formed below an upper surface of a substrate, the photodiode comprising at least two layers of Si alternating with at least two layers of Si_xGe_{1-x}, wherein the Si layers are not in direct contact with one another and the Si_xGe_{1-x} layers are not in direct contact with one another, and wherein the layers are configured to promote ionization by a first carrier type and suppress ionization by a second carrier type in the

presence of an electric field" and "a gate of a transistor adjacent to the photodiode, the transistor for transferring the amplified charge from the photodiode."

For at least the reasons presented with respect to claim 1, Lee, Chu and Nakamura do not render claims 20 and 32 obvious. As noted above, Tasumi is cited as disclosing the differences between the valence band energies and the conduction band energies, and does not cure the deficiencies of Lee, Chu and Nakamura. For at least these reasons, Applicant respectfully requests withdrawal of this rejection.

Claims 30, 31, and 35-37 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Lee in view of Chu, Nakamura, Tasumi, and in further view of U.S. Patent No. 6,232,626 to Rhodes.

Claims 30 and 31 depend from claim 20 and are allowable for all the reasons presented for claim 20, and on their own merits. For claim 30, Rhodes is cited as disclosing readout circuitry connected to a floating diffusion region for reading out charge, and fails to cure the deficiencies of the other references. For claim 31, Rhodes is cited as disclosing circuitry peripheral to the array, the peripheral circuitry being at a surface of the substrate where the substrate is silicon-on-insulator, and fails to cure the deficiencies of the other references.

Like claims 1 and 20, claim 35 recites "a photodiode formed below an upper surface of a substrate, the photodiode comprising at least two layers of Si alternating with at least two layers of Si_xGe_{1-x}, wherein the Si layers are not in direct contact with one another and the Si_xGe_{1-x} layers are not in direct contact with one another, and wherein the layers are configured to promote ionization by a first carrier type and suppress ionization by a second carrier type in the presence of an electric field" and "a gate of a transistor adjacent to the photodiode, the transistor for transferring the amplified charge from the photodiode."

For the same reasons discussed in connection with claims 1 and 20, non of Lee, Chu, Nakamura and Tasumi, even when considered in combination, do not teach or suggest all

limitations of the present claims and are not combinable to achieve the presently claims structures. Rhodes is cited as disclosing a processor system including a processor coupled to the image sensor and with readout circuitry electrically connected to the floating diffusion region, and fails to cure the deficiencies of the other references. For at least these reasons, Applicant respectfully requests withdrawal of this rejection.

Claim 55 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Lee in view of Nakamura. The rejection is respectfully traversed.

Like claim 1, claim 55 recites a pixel cell for an image sensor, the pixel cell comprising "a photodiode for generating charge in response to light and for amplifying the generated charge, the photodiode being formed within a trench in a substrate and comprising at least two of a first layer having a first band gap and at least two of a second layer having a second band gap, wherein the first layers are alternated with the second layers, wherein the first material layers are not in direct contact with one another and the second material layers are not in direct contact with one another, and wherein the at least two first layers and the at least two second layers are configured to promote ionization by a first carrier type and suppress ionization by a second carrier type in the presence of an electric field."

Claim 55 is allowable for at least the reasons discussed above in connection with claim 1. For at least these reasons, Applicant respectfully requests that this rejection be withdrawn.

In view of the above amendment, applicant believes the pending application is in condition for allowance.

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Respectfully submitted,

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